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CHAPPLE HAIR STYLING SALON
GARFIELD HEIGHTS, OHIO

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I. SUMMARY

On February 14, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the owner of Chapple Hair Styling Salon, Garfield Heights, Ohio, to conduct a Health Hazard Evaluation (HHE) to evaluate the potential for respiratory problems associated with exposures to hair care products.

On December 4-7, 1990, an environmental/medical evaluation was conducted. Samples were collected to qualitatively screen and identify volatile organic chemicals (VOCs) in the general workroom air. Air samples were also collected to assess general workroom concentrations and personal exposures to specific components of permanent wave products and hair sprays. Temperature and relative humidity measurements were also collected to evaluate thermal comfort.

A self-administered symptom questionnaire was completed by all 33 employees. Four individuals reported a history of physician-diagnosed asthma; three were diagnosed prior to their initial employment as hair stylists. Thirteen (39%) of 33 employees, reported at least two symptoms consistent with a diagnosis of current asthma (shortness of breath, chest pain or tightness, cough, or wheeze) in the preceding month. Eight (62%) of the 13 workers who reported two or more symptoms associated hair care products with symptom occurrence. Hair sprays were most frequently associated with respiratory symptoms, followed by powder bleaches, permanent solutions and hair dyes, and liquid hair bleaches respectively. Sixteen employees (48%) completed peak flow testing. None of the peak flow results revealed the reversible obstructive airway pattern usually attributable to work-related asthma.

General-area air samples collected for qualitative screening for volatile organic chemicals (VOCs) showed ethanol to be the only major chemical compound identified. Other compounds identified included acetone, ethyl acetate, n-butyl acetate, isopropanol, methyl ethyl ketone, toluene, and 1,1,1-trichloroethane. These chemicals are present in hair sprays, nail polishes, nail polish removers, and other products used in the salon. Based on these results, quantitative samples were analyzed for butyl acetate, ethanol, ethyl acetate, isopropanol, toluene, and 1,1,1-trichloroethane. All were detected at concentrations less than 1% of the applicable environmental criteria, with the exception of the alcohols (ethanol and isopropanol), which were less than 11% of the environmental criteria.

Ammonia was the only chemical ingredient of **permanent wave products** to be detected in quantifiable concentrations. The highest concentration detected (3.1 ppm), a short-term personal-breathing-zone (PBZ) air sample collected during the application of a permanent wave product, was less than 10% of the NIOSH short-term exposure limit (35 ppm). All long-term air samples for ammonia were less than 2% of the NIOSH Recommended Exposure Limit (REL). Sampling for decomposition products of thioglycolic acid detected acetic acid, but the amount was not quantifiable, and all hydrogen sulfide samples were nondetectable.

Sampling for **hair sprays** detected ethanol and isopropanol on all long-term samples collected specifically for these alcohols. The highest ethanol concentration found was less than 3% of the NIOSH REL (1000 ppm), while the highest isopropanol concentration detected was less

than 1% of the NIOSH REL (400 ppm). Two short-term samples detected ethanol (120 ppm and 106 ppm), but did not detect isopropanol. There is no STEL for ethanol, however the concentrations found are still only about 10-12% of the NIOSH REL. All total and respirable particulate samples were less than 0.1 mg/m^3.

Indoor CO_2 concentrations rose throughout the day, on the two days of the survey, with many values exceeding the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) recommendations. Many temperature and relative humidity readings were outside of the ASHRAE recommendations for winter, particularly in the early morning hours, in most cases because of low temperatures. However, the heating, ventilating and air-conditioning (HVAC) system serving the northeastern portion of the salon was not operational at the time of the initial survey.

On April 17-19, 1991, airflow measurements were collected to further evaluate the HVAC systems. At the time of this survey all air-handling systems were operational and all temperature and relative humidity measurements were within the ASHRAE comfort zone for summer. The total outside-air intake rate of the three HVAC systems serving the salon was less than 1000 cubic feet per minute (cfm). ASHRAE recommends 25 cfm per person for beauty salons. Based on the maximum number (48) of patrons and cosmetologist expected in the salon at any given time, the recommended rate should be about 1200 cfm of outside air.

Environmental data obtained during this evaluation indicated that no exposures occurred that were higher than existing **industrial** evaluation criteria. The evaluation of the HVAC systems indicated that additional outside-air should be supplied to the salon to meet the minimum ASHRAE recommendations. Thirteen (39%) of the 33 employees reported experiencing at least two symptoms consistent with asthma in the month prior to the first NIOSH visit, and eight of the 13 (62%) employees associated the onset of symptoms with exposure to hair care products. No reversible obstructive airway patterns suggestive of work-related asthma were found among the 16 employees who completed peak flow testing. However, the number of reported lower respiratory symptoms suggest that the existing **industrial** evaluation criteria may not be adequate to protect all exposed persons against the irritant effects of the combinations of chemicals used in hair salons. Additionally, the present ASHRAE recommendation of 25 cfm/person of outside air may be inadequate.

KEYWORDS: SIC 7231 (Beauty Shops), ammonia, beauty salons, beauticians, cosmetology, cosmetologists, hair dressers, hair sprays, permanent wave products, thioglycolic acid, ventilation.

II. INTRODUCTION

On February 14, 1989, the National Institute for Occupational Safety and Health (NIOSH) received a request from the owner/operator of the Chapple Hair Styling Salon, Garfield Heights, Ohio, to conduct a Health Hazard Evaluation (HHE). The requestor was concerned about potential respiratory problems associated with exposure to hair care products.

On December 4-7, 1990, an environmental/medical evaluation was conducted. Samples were collected to qualitatively screen and identify volatile organic chemicals (VOCs) present in the general workroom air. Additionally, long-term and short-term air samples were collected specifically for the following chemicals: ammonia, acetic acid, alkaline dusts, formaldehyde, hydrogen sulfide, ethyl alcohol, isopropyl alcohol, total particulates, respirable particulates, and carbon dioxide (CO_2). Temperature and relative humidity readings were also collected to evaluate thermal comfort. The medical evaluation consisted of a self-administered questionnaire and peak flow testing. The results of carbon dioxide (CO_2), temperature, and relative humidity measurements were transmitted verbally at the closing conference on December 7, 1990.

On April 17-19, 1991, NIOSH investigators returned to conduct airflow measurements to evaluate the heating, ventilating, and air-conditioning (HVAC) systems. Additionally, carbon dioxide (CO_2), and temperature and relative humidity readings were collected throughout the salon. The preliminary results of this survey were discussed with the owner/operator of Chapple Hair Styling Salon during the closing conference on April 19, 1991.

III. PROCESS DESCRIPTION

Chapple Hair Styling Salon is a full service salon located in a detached single story building. The building is constructed of brick and was built in 1946. The present owner purchased the building in 1976, renovated the north half of the building for use as a beauty salon, and opened for business the same year. The south half of the building was leased to a bakery and later to an insurance company. In 1980, the salon expanded to occupy approximately 3/4 of the building, and in 1987 the salon further expanded and since then has occupied the entire building. The building layout includes a reception and waiting area at the front of the building, two hairstyling areas, two restrooms in the back, a break room and laundry area in the back, and a dispensary room in the center of the building. The two hairstyling areas have a total of 19 styling stations and are separated by a floor to ceiling wall down the center of the building. Some hair care products are mixed in the dispensary and all hairstyling products are stored in the dispensary, as required by the Ohio State Board of Cosmetology. At the time of the NIOSH surveys the salon employed 33 individuals, including 25 full- and part-time cosmetologists, 5 receptionists, 2 managers, and 1 director. The salon is open for business from 9:00 am to 9:00 pm.

The building is served by three separate HVAC systems, each with an air-handling unit (AHU) and the necessary ductwork, controls, and other hardware. Each AHU contains, at minimum, a fan, a filter, and a cooling (evaporator) coil (which is provided with refrigerant from an electric-powered mechanical compressor). All three systems utilize the above-ceiling plenum area as the air return, and air enters the plenum through numerous egg-crate-style grilles scattered throughout the facility's ceiling. Each system also has a network of supply-air ducts (located above the ceiling) which feed supply-air diffusers mounted in the ceiling.

Specifics of the three systems are described in the following text.

1. The first system serves the south half of the building. It has a Ruud® rooftop package AHU, with 5 tons of cooling capacity and a gas-fired heating unit. The rooftop unit also contains the compressor, condenser, etc., all in one package. Air is drawn from the return plenum through a duct (which passes through a roof opening), and enters the unit, where it is mixed with outside air inducted through a grille in the unit. This air mixture is conditioned (heated or cooled), then discharged to the main supply duct (which also passes through the roof, to the system's supply duct network). This is a constant-volume system (as long as the fan control is left in the "on" position, as is reportedly the practice) with a rated total-supply volumetric airflow rate of 2500 cubic feet per minute (cfm) and an outside-air intake rate reported, at the time of the survey, to be approximately 500 cfm. (If the fan control is switched to the "automatic" position, then no outside-air induction, nor any airflow, occurs unless heating or cooling is being called for by the thermostat). The outside-air intake has a manually-adjustable damper which is locked into position after adjustment, so the outside-air intake rate is otherwise constant. Reportedly, this flowrate is re-adjusted to a lower rate during the winter.

2. The second system serves primarily the eastern portion of the north half of the building. It has a General Electric AHU and refrigeration system, also with 5 tons of cooling capacity, and electric-resistance-coil heating strips in the main supply duct. It is functionally quite similar to the Ruud package unit, and its rated supply-air flowrate and reported (at the time of the survey) outside-air intake rate are the same as those of the Ruud system. However, its physical configuration differs in that it is a split system — the AHU is located inside the northeast corner of the building, hanging from the roof in the overhead area, while a portion of the refrigeration system (the compressor, condenser, etc.) is separately located in an outdoor unit mounted on the roof. The outside air intake grille for this system is located in the outside wall on the rear of the building, near the roof, and after entering this grille the outside air passes through a duct to reach the AHU. It was noted that the outside-air intake duct was blocked by a wad of fiberglass-insulation material at the time of the survey, until the HVAC contractor for Chapple removed it. Reportedly, the outside-air intake rate for this system is also manually re-adjusted to a lower rate during the winter.

3. The third system serves the western portion of the north half of the building. It has a General Electric AHU and refrigeration system, with no heating capability. This system handles only 100%–recirculated air, and is therefore not of great importance in this evaluation. It is a constant-volume system.

Other air handling devices in the building include two ceiling-mounted particulate air cleaners that handle only 100%–recirculated air, a ceiling-mounted exhaust fan in the dispensary which discharges into the ceiling plenum only (and thus effectively handles only 100%–recirculated air), and two dilution-type exhaust-ventilation systems. These two exhaust systems each have a roof-mounted Jennaire fan which draws room air into an egg-crate-style intake grille in the ceiling and through a duct to the roof where it is discharged to the outdoors. The fans are each reportedly rated at an airflow rate of 500 cfm. One system's intake is in the south half of the building, and the other is near the northwest corner.

IV. EVALUATION DESIGN AND METHODS

A. Industrial Hygiene Sampling

To determine the types of air contaminants that may be present at this salon, Material Safety Data Sheets (MSDSs) of commonly used beauty products were obtained and reviewed prior to the site visit. Also, conversations with the requestor indicated that the most frequently used products at this salon are hair sprays and permanent wave products. Based on this information, it was decided that this evaluation would focus on exposures to ingredients commonly found in hair sprays and permanent wave products.

A review of the MSDSs for **permanent wave products** indicated that thioglycolic acid is generally present in permanent wave products in concentrations ranging from 1% to 10%. Also, ammonia thioglycolate and hydroxides are often present in permanent wave products. **Aerosol hairsprays** generally contain alcoholic solutions of polymers, minor ingredients and propellants in a pressurized container. Formaldehyde is often present in many cosmetic products (e.g. shampoos) as a preservative and is also present in many construction materials, therefore, formaldehyde samples were also collected. Because of the multitude of chemical products used in beauty salons it was not possible to evaluate all of them.

Before conducting a field survey to evaluate exposures to thioglycolic acid, a sampling method needed to be developed for this analyte. The NIOSH Division of Physical Sciences and Engineering (DPSE) attempted to develop a sampling method for thioglycolic acid, but the effort was unsuccessful because of the reactivity of this chemical. Because thioglycolic acid readily decomposes to acetic acid and hydrogen sulfide, an attempt was made to measure these chemical substances, as well as ammonia, which is often present in permanent wave products.

On December 4-7, 1990, air samples were collected to assess general workroom concentrations and personal exposures to components of permanent wave products and hair sprays. Personal-breathing-zone air samples were collected for ammonia, acetic acid, hydrogen sulfide, and alkaline dusts to evaluate exposures to permanent wave products. To evaluate personal exposures to ingredients contained in hair sprays, samples were collected for alcohols, as well as, total and respirable particulate materials. Additionally, the salons' ventilation systems were evaluated by collecting CO_2, temperature, and relative humidity readings at 18 locations throughout the salon and, for comparison, outside the building.

To evaluate airborne concentrations of contaminants present in the general workroom air, several sampling pumps along with the appropriate sampling media were placed in groups at three locations within the salon. Each sample group included sampling media for qualitative and quantitative screening for VOCs, as well as, the following specific compounds, some of which are VOCs: ammonia, acetic acid, alkaline dusts, formaldehyde, hydrogen sulfide, ethyl alcohol, isopropyl alcohol, total particulates, and respirable particulates.

Qualitative and quantitative samples for VOCs were collected on charcoal tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.05 liters per minute (lpm). These samples were analyzed via gas chromatography/mass spectrometry (GC/MS). Qualitative samples were screened for organic chemical compounds and quantitative samples were analyzed for specific compounds as indicated by the results of the qualitative analyses.

Ammonia samples were collected using a modification of NIOSH Method No. S347.[1] Samples were collected on sulfuric acid treated silica gel solid sorbent tubes connected in series to a 37-millimeters (mm) polytetrafluorothylene (PTFE) prefilter to remove ammonia salt particulates. The prefilter and solid sorbent tubes were connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.1 lpm. Alkaline phenol and sodium hypochlorite were added to the samples to form indophenol in proportion to the ammonia concentration; the solutions were then analyzed by visible spectrophotometry. The intensity of the blue-colored indophenol was measured at 630 nanometers.

Acetic acid samples were collected on solid sorbent charcoal tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.2 lpm. These samples were analyzed for acetic acid via gas chromatography according to NIOSH Method No. 1603.[2]

Hydrogen sulfide samples were collected on Drager long-term direct reading detector tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.02 lpm. The hydrogen sulfide concentration present was determined by visually measuring the length of stain on the detector tube.

Several permanent wave products often contain hydroxides, therefore alkaline dust samples were also collected. Alkaline dusts samples were collected on PTFE filters connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1.0 lpm. The samples were analyzed for alkaline dusts by titration according to NIOSH Method No. 7401.[2]

Ethyl alcohol and isopropyl alcohol samples were collected on solid sorbent charcoal tubes connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 0.05 lpm. These samples were analyzed for both ethyl alcohol and isopropyl alcohol via gas chromatography according to NIOSH Method No. 1400.[2]

Total particulate samples were collected on pre-weighed polyvinyl chloride (PVC) filters connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 2.0 lpm. Respirable particulate samples were collected on pre-weighed PVC filters attached to a 10-mm cyclone and connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1.7 lpm. The filters were analyzed gravimetrically for total and respirable particulate according to NIOSH Methods 0500 and 0600,[2] respectively.

Formaldehyde samples were collected using impingers (containing an aqueous 1% sodium bisulfite solution) connected via Tygon® tubing to battery-powered sampling pumps calibrated to provide a volumetric airflow rate of 1 lpm. Sodium bisulfite solutions were analyzed for formaldehyde by reaction with chromotropic acid and subsequent visible absorption spectrophotometry in accordance with NIOSH Method No. 3500.[2]

Other indicators of indoor air quality are CO_2, temperature, and relative humidity. Carbon dioxide (CO_2) samples were obtained using a Gastech direct reading portable CO_2 Monitor (Model RI411). Indoor CO_2 concentrations were obtained at 18 locations throughout the salon and outside the building for comparison. Temperature and relative humidity data were collected in conjunction with CO_2 measurements in all areas where airborne sampling was conducted, using a Vista Scientific Corporation psychrometer (Model #784).

B. Evaluation of Ventilation Systems

On April 17 through 19, 1991, NIOSH investigators evaluated the ventilation systems serving the Salon. This evaluation included visual inspections as well as the measurement of outside-air intake and exhaust-air flowrates. The systems' performance was additionally evaluated by collecting CO_2, temperature, and relative humidity readings at five locations throughout the salon (and, for comparison, outside the front and back of the building).

Accessible parts of the AHUs (e.g., mixed air chambers and filters) and duct work were inspected visually. Also, smoke-generating tubes were used to visualize air flow patterns.

Outside-air intake rates were measured at the outside-air intake grilles using a Shortridge Flow Hood and meter (MN 86BP) equipped with a temperature probe to compensate for temperature. This instrument also compensates for barometric pressure and the flow restriction caused by the instrument itself. The instrument was also used to measure exhaust flowrates at the intake ends of the exhaust ducts.

Carbon dioxide, temperature, and relative humidity measurements were repeated during the ventilation survey. The Gastech direct-reading CO_2 meter, set in the 60–sec average mode, was used to measure airborne CO_2. The air temperature and relative humidity were measured using a hand-held, direct-reading, electronic Vaisala HM34 Humidity and Temperature Meter.

C. Medical Questionnaire

All 33 employees were requested to complete a self-administered questionnaire that addressed respiratory symptoms, and was based on previous questionnaires used by NIOSH in evaluating occupational asthma in the workplace.[3,4] Participants were asked to report the presence or absence of respiratory symptoms occurring in the last month. Information was sought on whether symptoms followed exposures to certain hair care products. Additional questions sought information on occupational history, smoking habits, and previous diagnosis of asthma.

D. Peak Expiratory Flow Testing

To identify changes in the amount of air that could be exhaled over time (both in and out of the workplace), NIOSH investigators instructed participants on how to measure peak expiratory flow rate (PEFR), using a mini-Wright portable flow meter. Peak flow refers to the amount of air in liters per minute that can be blown through the flow meter in one sharp breath. Peak expiratory flow rates were measured, for a 1 week period, every 3 hours while the participant was awake and during the night if she or he was awakened for any reason. Three exhalations were recorded each time, and the maximum of the 3 was recorded as the PEFR determination. Any wheezing, shortness of breath, chest tightness or cough experienced at the time of a PEFR determination was supposed to be reported on the peak flow record. A participant was considered to have significant bronchial obstruction if the difference between the minimum and the maximum PEFR on at least 1 day exceeded 20% of the day's maximum PEFR.[5] Reversible bronchial obstruction occurs with asthma, but it may also be due to acute illness unrelated to asthma such as an upper respiratory infection or bronchitis.

V. EVALUATION CRITERIA

A. Environmental Evaluation Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Recommended Exposure Limits (RELs),[6] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[7] and 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards.[8] The OSHA standards may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH RELs, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is required by the Occupational Safety and Health Act of 1970 (29 USC 651, et seq.) to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high, short-term exposures.

B. Acetic acid

Acetic acid vapor is an irritant of the eyes, mucous membranes, and skin. The primary route of exposure is through inhalation of the vapor, but it can also affect the body if it comes in contact with the eyes or skin, or by ingestion.[9] The current OSHA PEL for acetic acid is 25 mg/m^3 averaged over an 8-hour work shift.[8] The NIOSH REL is 25 mg/m^3 for up to a 10-hour work shift and a 15-minute STEL of 37 mg/m^3.[10]

C. Hydrogen sulfide

Hydrogen sulfide is an irritant of the eyes and respiratory tract. The primary route of exposure is through inhalation.[9] The current OSHA PEL for hydrogen sulfide is 10 ppm averaged over an 8-hour work shift with a STEL of 15 ppm.[8] The NIOSH REL is 10 ppm averaged over a 10-minute period.[6]

D. Isopropanol (isopropyl alcohol)

Isopropanol is an irritant of the eyes and mucous membranes. The primary route of exposure is through inhalation, but it can also affect the body if it comes in contact with the eyes or skin, or by ingestion.[9] The OSHA PEL for isopropanol is 980 mg/m^3 averaged over an 8-hour work shift with an STEL of 1225 mg/m^3 averaged over a 15-minute period.[8] The NIOSH REL is 980 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling limit of 1225 mg/m^3 averaged over a 15-minute period.[10]

E. Ethanol (ethyl alcohol)

Ethanol is an mild irritant of the eyes and mucous membranes. The primary route of exposure is through inhalation, but can also affect the body if it comes in contact with the eyes or skin, or by ingestion. The liquid can defat the skin, producing a dermatitis characterized by drying and fissuring.[11] The OSHA PEL for ethanol is 1900 mg/m^3 averaged over an 8-hour work shift.[8] The NIOSH REL is 1900 mg/m^3 averaged over a work shift of up to 10 hours per day.[10]

F. Ammonia

Ammonia, NH_3, is a colorless, strongly alkaline, and extremely soluble gas with a characteristic pungent odor.[11] Ammonia is a severe irritant of the eyes, respiratory tract, and skin.[9] The NIOSH REL for ammonia is 25 ppm as a TWA for up to a 10-hour workday and 35 ppm as a 15-minute STEL.[10] The ACGIH TLV is 25 ppm as an 8-hour TWA and 35 ppm as a 15-minute STEL, and the OSHA PEL is 35 ppm as a 15-minute STEL.[7,8]

G. Formaldehyde

Formaldehyde is a colorless gas with a strong, pungent odor detectable at low concentrations. It is commonly utilized as formalin, an aqueous solution containing 37-50% formaldehyde by weight.[12] It is widely used in the production of resins, in the manufacture of many other compounds, as a preservative, as a sterilizing agent, and as an embalming fluid.[13] In some states, the use of formaldehyde cabinet fumigants is required. These fumigants are generally in the form of paraformaldehyde tablets or are prepared with formalin solutions (37% formaldehyde).[14,15]

Exposure to formaldehyde can occur through inhalation or skin absorption.[9] The primary non-carcinogenic effects associated with formaldehyde exposure are irritation of the mucous membranes of the eyes and respiratory tract, and allergic sensitization of the skin. Dermatitis due to skin contact with formaldehyde solutions and formaldehyde-containing resins is a well-recognized problem. Both primary skin irritation and allergic dermatitis have been reported.[12]

NIOSH recommends that formaldehyde be handled as a potential occupational carcinogen and that appropriate controls be used to reduce worker exposure to the lowest feasible level. This recommendation is based primarily on a study in which nasal cancers developed in rats and mice following repeated inhalation exposures of approximately 15 ppm formaldehyde.[16] The OSHA PEL is 1 ppm, as an 8-hour TWA with a 15-minute STEL of 2 ppm.[17] ACGIH has given formaldehyde an A2 designation, indicating that ACGIH considers formaldehyde a suspected human carcinogen. The ACGIH TLV for formaldehyde is 1 ppm as an 8-hour TWA and 2 ppm as a 15-minute STEL.[7] ACGIH has recently proposed a ceiling limit of 0.3 ppm formaldehyde in their notice of intended changes for 1989-1990.[7] This value will be reconsidered for the adopted TLV list after 2 years.

H. Heating Ventilating and Air-Conditioning (HVAC) Systems

The outside air ventilation criteria recommended by NIOSH investigators are those published by the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) in the ASHRAE Standard on Ventilation for Acceptable Indoor Air Quality (ASHRAE 62-1989).[18] Table 2 of that document specifies outdoor (fresh) air requirements for ventilation in commercial facilities. ASHRAE recommends an outside air ventilation rate of 25 cfm/person for Beauty Shops.

I. Temperature and Relative Humidity

The perception of thermal comfort is related to one's metabolic heat production, the transfer of heat to the environment, physiological adjustments, and body temperatures. Heat transfer from the body to the environment is influenced by factors such as temperature, humidity, air movement, personal activities, and clothing. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) has published guidelines describing thermal environmental conditions for comfort (ASHRAE Standard 55-1981, Thermal Environmental Conditions for Human Occupancy).[19] These guidelines are intended to achieve thermal conditions that will be found acceptable or comfortable by at least 80% of the population. The temperatures range from 68°F to 74°F in the winter, and from 73°F to 79°F in the summer. The difference between the two is largely due to seasonal clothing selection. ASHRAE recommends that relative humidity be maintained between 30% and 60%.[18] Excessive humidity can support the growth of pathogenic and allergenic microorganisms.[18]

J. Carbon Dioxide

Carbon dioxide (CO_2) is a normal constituent of exhaled breath and, if monitored, can be used as a screening technique to evaluate if adequate quantities of fresh air are being introduced into a building. For example, the outdoor ambient concentrations of CO_2 is usually 250-300 ppm. If the indoor CO_2 concentration was determined to be 1000 ppm, or 3-4 times the outdoor level, inadequate ventilation would be suspected. Carbon dioxide concentrations are generally higher inside than outside, even in a well ventilated building. It is not uncommon to find the inside levels twice the outside levels in a building with no reported health complaints. The CO_2 concentration itself is not responsible for the complaints. However, a high concentration of CO_2 may indicate that other contaminants in the building may also be increased. When the inside CO_2 concentrations are 3 or more times the outside CO_2 concentrations, complaints of headache, eye irritation, and fatigue can be expected. If CO_2 concentrations are maintained below 600 ppm, with comfortable temperature and humidity levels, complaints about air quality should be minimal unless there is a specific contaminant source that requires additional control such as, certain cosmetology products.[20]

K. Occupational Asthma

Asthma, a lung disorder characterized by reversible obstruction of the lung airway system (called the bronchial tubes) causes intermittent respiratory symptoms, including shortness of breath, wheezing, chest tightness, and cough. In occupational asthma, airway obstruction is caused or made worse by workplace exposure to dusts, fumes, gases, or vapors.[21] In the U.S., asthma occurs in about 5% of the general population; 2% of these cases are thought to be occupational.[22] Common mechanisms of occupational asthma include:

1. Direct airway irritation (reflex bronchoconstriction)

   In this type of occupational asthma, the airways of the lung are irritated by many nonspecific agents such as cold air, dust particles, gases, and fumes. This type does not involve the body's immune system, and in most cases, the individual has a history of asthma prior to any occupational exposure. These people are considered to have abnormally reactive airways, and they generally develop symptoms of shortness of breath, chest tightness, cough, and wheezing immediately after exposure to occupational or other agents. Symptoms can occur following exposure to extremely low concentrations of the irritant.

   A large number of irritant chemicals are present in hair care products. Compounds that are routinely used in hair salons, such as include acetic acid, hydrogen sulfide, alcohols, ammonia and formaldehyde, as well as cigarette smoke, could produce irritant-mediated occupational asthma.

2. Inflammatory bronchoconstriction

   This type results from inhalation of irritant gases and vapors in very high concentrations. The irritant gases cause damage to the cells lining the bronchial airways and result in an "inflamed" airway. The individual has symptoms of shortness of breath, wheezing, chest tightness, and cough. Symptoms usually resolve within several weeks, but in some individuals the symptoms can persist following exposure (over extended periods) to low levels of many non-specific irritants. It seems unlikely that, under usual circumstances in a hair salon, that concentrations of irritant gases would reach levels high enough to produce inflammatory bronchoconstriction.

3. Allergic bronchoconstriction or Type I hypersensitivity

This is the most common type of occupational asthma. Susceptible workers develop antibodies after being exposed to substances at work, and repeated exposure causes asthma to develop. The time between developing asthma symptoms after exposure to the workplace substance can vary from weeks to years. Once asthma has developed, symptoms may occur immediately after exposure, following a delay of several hours, or in a pattern with both early and late components. Products that contain chemical allergens that have been associated with hypersensitivity in hairdressers include persulphate salts, dyes containing paraphenylenediamine, and permanent wave solutions.[23,24]

VI. RESULTS

A. Industrial Hygiene Survey

The results of general-area and personal-breathing-zone air samples collected on December 4-7, 1990, are summarized below.

General-area air samples collected for qualitative screening for volatile organic chemicals (VOCs) via GC/MS showed ethanol (ethyl alcohol) to be the only major chemical compound identified. Other compounds identified include acetone, ethyl acetate, n-butyl acetate, isopropanol, methyl ethyl ketone, toluene, and 1,1,1-trichloroethane. These chemical compounds are present in many of the products used in the salon including hair sprays, nail polishes, nail polish remover, and other products.

Based on qualitative screenings for VOCs, 21 quantitative samples for VOCs were analyzed for ethanol, isopropanol, ethyl acetate, butyl acetate, toluene, and 1,1,1-trichloroethane. The ethanol and isopropanol concentrations detected on these samples agreed with the concentrations detected on samples collected specifically for the alcohols, as discussed below. Ethyl acetate was detected on two samples, the highest concentration detected was 0.4 ppm, less than 1% of the NIOSH, OSHA, and ACGIH criteria of 400 ppm. N-butyl acetate was detected on one sample, the concentration found was less than 1% of the NIOSH, OSHA, and ACGIH criteria of 150 ppm. Toluene was detected on 5 samples, 2 contained quantifiable concentrations, the highest concentration detected was less than 1% of the NIOSH, OSHA, and ACGIH criteria of 100 ppm. 1,1,1-Trichloroethane was found on one sample, however the concentration found was not quantifiable. Two short-term samples collected during hair spray application showed no detectable concentrations of any chemical included in the analyses except ethanol, which was found in concentrations of 86 ppm and 111 ppm. There is no short-term exposure criteria for ethanol, but when compared to the long-term criteria, the concentrations found are still only about 10% of the NIOSH, OSHA, and ACGIH criteria.

Permanent wave products

Results of air sampling for ingredients of permanent wave products are summarized below. Ammonia sample results showed that 13 of 16 samples collected had detectable ammonia concentrations. Sample concentrations ranged from nondetectable to 2.6 ppm on the solid sorbent silica gel tubes. Additionally, five of the thirteen samples showing detectable concentrations also showed trace quantities (between the analytical LOD and LOQ) of ammonia on the prefilter. When adding the amount of ammonia detected on both the prefilter and the silica gel tubes, the highest concentration found is 3.1 ppm. This sample was on a short-term personal-breathing-zone air sample collected during the application of a permanent wave product. When compared to the NIOSH REL for short-term exposures, the amount present was less than 10% of the criteria. All long-term samples collected were less than 0.5 ppm or 2% of the NIOSH REL. Alkaline dust sample results showed no detectable concentrations on any of the six samples collected.

Sampling for decomposition products of thioglycolic acid showed detectable concentrations of acetic acid on only two of 15 samples collected, but the amount of acetic acid detected was not quantifiable, and all hydrogen sulfide samples were nondetectable.

Hair sprays

Samples collected specifically for ethanol and isopropanol agreed with concentrations found on quantitative samples for VOCs. Ethanol and isopropanol were detected on all long-term samples collected. Two short-term samples collected showed only ethanol. Long-term ethanol concentrations ranged from 8.3 ppm to 22 ppm, the highest concentration found was less than 3% of the NIOSH REL, OSHA PEL, and ACGIH TLV of 1000 ppm. Isopropanol concentrations ranged from nondetectable to 3.5 ppm, the highest concentration detected was less than 1% of the NIOSH REL, OSHA PEL, and ACGIH TLV of 400 ppm. Two short-term samples collected showed ethanol concentrations of 120 ppm and 106 ppm. There is no short-term exposure criteria for ethanol, but when comparing these concentrations to the long-term criteria they are still only about 10% - 12% of the NIOSH, OSHA, and ACGIH criteria of 1000 ppm.

All total particulate and respirable particulate samples collected showed concentrations less than 0.1 mg/m^3.

Formaldehyde

The results of general-area sampling for airborne formaldehyde showed that only two of six samples collected had detectable concentrations, however the amount of formaldehyde detected was less than the analytical limit of quantitation.

Carbon dioxide, Temperature, Relative Humidity

The results of CO_2, temperature and relative humidity measurements collected on December 5th and 6th, 1990, are presented in Table I and are summarized below. It should be noted that the General Electric HVAC system serving the northeastern portion of the building was not operational at the time these measurements were collected.

Indoor CO_2 concentrations on December 5, 1990, ranged from 600 ppm to 2050 ppm. On December 6, 1990, indoor CO_2 concentrations ranged from 700 ppm to 1400 ppm. The outdoor CO_2 concentrations on these two days were within the normal range for outdoor environments. These data showed that the indoor CO_2 concentrations rose throughout the day during the two days sampling was conducted and several concentrations found exceeded the ASHRAE guidelines for indoor CO_2 concentrations.

Indoor temperature and relative humidity readings were collected at 18 locations throughout the salon on the two days of sampling. Indoor temperatures on December 5, 1990, ranged from 61°F to 75°F with relative humidities ranging from 28% to 70%. On December 6, 1990, indoor temperature and relative humidity readings ranged from 64°F to 74°F and 31% to 50%, respectively. Many of the readings recorded throughout the salon on these two days were outside the ASHRAE comfort zone (winter range), particularly in the early morning hours, in most cases because of low temperatures.

B. Ventilation Survey

Results of the CO_2, temperature and relative humidity measurements collected during April 1991, are presented in Table I and are summarized below. The salon was occupied by about 25 to 30 people during the time measurements were collected, and all air-handling systems (i.e., both the exhaust systems and the HVAC systems) were in operation.

The outside-air intake rate of the Ruud rooftop package unit was measured at 500 cfm. The outside-air intake rate of the General Electric system serving primarily the eastern portion of the north half of the building was difficult to measure, but was estimated to be approximately 400 cfm after the wad of fiberglass-insulation material blocking it was removed by the HVAC contractor. The exhaust airflow rates for the two dilution-type exhaust-ventilation systems were measured at 335 and 405 cfm, for the system in the south half of the building and the one near the northwest corner, respectively.

Air flow patterns visualized with smoke-generating tubes at the front entrance and left rear entrance showed air movement into the building.

During the ventilation survey, temperature readings within the salon ranged from 73.5°F to 75°F and relative humidity readings ranged from 33% to 34%. These readings are all within the ASHRAE comfort zone (summer range). Outside temperature and relative humidity readings were 63°F and 31% in front of the building, 60.5°F and 35% behind the building, and 52°F and 46% on the roof. Carbon dioxide measurements within the salon ranged from 725 to 775 ppm. The outdoor CO_2 concentrations were 375 ppm in the front of the building (nearer a main road) and 350 ppm in the back of the building.

C. Medical Questionnaire Results

At the time of the environmental/medical survey of December 1990, the Chapple Hairstyling Salon employed 33 individuals; 32 (97%) were female. All 33 completed the questionnaire. The median number of years employed in the hair styling business was 7.5 years. Four persons reported a history of physician-diagnosed asthma; three were diagnosed prior to their initial employment as hair stylists. All employees were considered to be potentially exposed to aerosols and vapors from the hair care products because the reception area opened into the styling area.

Thirteen (39%) of the 33 employees reported having of at least two symptoms consistent with a diagnosis of current asthma (shortness of breath, chest pain or tightness, cough, or wheeze)[25,26] in the previous month. All four persons with diagnosed asthma reported symptoms within the past month. Among the 13 workers who reported at least two symptoms, nine (69%) were nonsmokers and four (31%) were current smokers. Smoking was not permitted at the salon. Eight (62%) of the 13 employees who reported symptoms associated them with occupational exposure to hair care products. Hair sprays were most frequently associated with respiratory symptoms, followed by powder bleaches, permanent solutions and hair dyes, and liquid bleaches, respectively (Table II).

D. Peak Flow Results

Peak flow results were returned by 21 (64%) of the staff, but complete recordings were provided by only 16 (48%).

A decrease of 20% was found in two hair stylists; neither had a history of physician-diagnosed asthma. One was completing antibiotic therapy for an upper respiratory infection, and the other reported that she had a "cold." The presence of an acute respiratory illness could have contributed to bronchial obstruction in the two individuals.

VII. DISCUSSION

A. Exposures to Chemical Agents

Services performed by hairdressers include haircutting, cleansing, conditioning, and corrosive treatments for the hair and scalp, as well as treatments designed to hold the hair in place or change its shape, configuration or color.[27] Cosmetologists also perform other beauty services such as massaging the face and neck with creams and oils, coloring eyebrows and lashes, manicuring fingernails and toenails, and hair removal by various techniques.[28]

Many chemical compounds contained in beauty products (e.g. hair sprays, permanent wave products, dyes, bleaches, etc.) are capable of causing skin irritation, respiratory problems including bronchial irritation and occupational asthma, and other adverse symptoms through inhalation and dermal absorption.[23,27,28,29] Epidemiological evidence also suggests an elevated risk of cancer at several sites (particularly bladder and lung) for hairdressers with exposure to hair-care products.[27,30,31]

Contact dermatitis is a well-recognized, and possibly the most frequent, occupational disease among cosmetologists. Dermatitis can seriously inhibit the effectiveness and ability of a beautician to perform the basic services of the profession.[32,33] Many of the products used by beauticians, including permanent wave solutions and oxidation-type hair coloring preparations, contain both dermal irritants and sensitizers. Oxidation-type hair coloring preparations may also be carcinogenic.[27]

The respiratory symptoms reported by hair stylists in this study are consistent with those reported in other studies of hair stylists.[23,34] Occupational asthma among hair stylists has been associated with persulphate salts used in hair bleaches, henna, and other hair dyes containing paraphenylenediamine.[23,29] In addition to shortness of breath, cough, wheezing, and chest discomfort, other symptoms including irritation of the mucous membranes of the eyes, nose, and throat, headache, nausea, and vomiting following exposure to various aerosols have been recorded.[23,24,34,39]

Thirteen (39%) participants, including the four persons with diagnosed asthma, reported having at least two symptoms suggestive of asthma within the preceding month. Two of the peak flow results revealed differences of greater than 20% between the maximum and minimum recordings for one day. However, both workers stated that they had current respiratory infections, so the peak flow results were not necessarily indicative of asthma. (Both workers were informed of their abnormal peak flow results and encouraged to discuss them with their physician.)

Peak flow meters have been used to demonstrate reversible airway obstructions associated with the work environment.[23,25,26] Often times, additional testing such as pulmonary function tests and various immunological tests are included in such studies. In this study, no patterns of occupationally-related bronchial obstruction were identified by peak flow testing. However, because of the poor completion rate of peak flow testing (48%), cases may have been missed. Among those workers who completed peak flow testing, ten reported symptoms and six did not. Among those who did not complete peak flow testing, nine reported symptoms and eight did not.

This health hazard evaluation focused on assessing chemical exposures of beauticians through inhalation of chemicals contained in hair sprays and permanent wave products and/or decomposition products of permanent wave products. The airborne concentrations of each individual chemical substance evaluated during this health hazard evaluation were all below their respective evaluation criteria. However, the number of reported lower respiratory symptoms suggest that the existing **industrial** evaluation criteria may not be adequate to protect all exposed persons against the irritant effects of the combinations of chemicals used in hair salons. Additionally, the present ASHRAE recommendation of 25 cfm/person of outside air may be inadequate.

The results of environmental sampling for ingredients and decomposition products of **permanent wave products** showed that ammonia was the only airborne chemical found in quantifiable concentrations. The highest ammonia concentration detected (3.1 ppm) was less than 10% of the NIOSH STEL (35 ppm) and all long-term samples collected were less than 2% of the NIOSH REL. Although peak exposures (instantaneous) were not measured, it is likely that peak exposures during permanent wave applications may have been higher and may be responsible for some of the irritation and odor complaints associated with the use of these types of products. Based on the sampling data collected, it is recommended that future investigations aimed at evaluating permanent wave products focus on peak ammonia concentrations. Acetic acid was also detected, but the concentrations found were not quantifiable. All samples for hydrogen sulfide and hydroxides were nondetectable.

Sampling for alcohols contained in **hair sprays** showed ethanol and isopropanol on all long-term samples collected. However, the highest long-term ethanol concentration found was less than 3% of the environmental criteria and the highest isopropanol concentration detected was less than 1% of the environmental criteria. The highest ethanol concentrations (120 ppm and 106 ppm) found were on short-term air samples collected during hair spray application; isopropanol was not found on these samples. There is no short-term exposure criteria for ethanol; but when compared to the long-term criteria, the concentrations found are still only about 10% - 12% of the applicable environmental criteria (1000 ppm). All total particulate and respirable particulate samples collected were less than 0.1 mg/m^3.

The airborne **formaldehyde** concentrations detected represent background levels. Formaldehyde cabinet fumigants were not used at this beauty salon. However, two NIOSH Indicative conducted at beauty schools within the vocational program of two public school systems focused on the use of formaldehyde cabinet fumigants and showed that the use of cabinet fumigants contributed to the formaldehyde concentrations found at these schools.[14,15] Any products or fixtures containing formaldehyde can contribute to airborne formaldehyde concentrations within the work environment. Therefore, the use of all products containing formaldehyde or any suspected or confirmed carcinogen should be discontinued where possible. In instances where this is not feasible, personnel should be protected by the use of engineering controls.

The basic principles for controlling airborne contaminants in the occupational environment consist of substitution, isolation, and ventilation. Product substitution and/or ventilation are the two choices best suited for controlling airborne contaminants in beauty salons. Product substitution (i.e., elimination) is the first and most effective method of controlling airborne contaminants and should be used if possible. In instances where product substitution is not feasible, local exhaust or dilution ventilation should be used to remove chemical contaminants generated from the various beauty products used.

B. Heating, Ventilating, and Air-conditioning

During the two days of the December 1990 survey, this beauty salon averaged 150.5 customers per day. The busiest times were from about 4:00 pm to 9:00 pm; from 9:00 am to 1:00 pm was the least busy time. During this survey, CO_2 measurements rose throughout the day and several concentrations exceeded the ASHRAE recommendation of 1000 ppm. Low temperature measurements were also recorded throughout the salon, particularly in the early morning hours. However, the General Electric HVAC system serving the northeastern portion of the building was not operational at the time of the initial survey and was, at least, partially responsible for the elevated CO_2 and low temperature readings recorded.

It should be emphasized that CO_2 concentrations are only one of the parameters used for assessing the effectiveness of ventilation systems and indoor air quality in office building environments. Elevated CO_2 concentrations can be used as an indicator of insufficient outside air being introduced to beauty salons; however, CO_2 concentrations alone can not be used to indicate that enough outside air is being introduced to a salon for two reasons: 1) office building environments generally do not have the major contaminant sources that are present in beauty salons; 2) ASHRAE recommends higher outside air rates for beauty salons than for office spaces, therefore CO_2 concentrations would likely be diluted to a greater extent by the higher rates required for beauty salons. ASHRAE recommends that outside air be provided at a rate of 25 cfm/person for beauty salons, as compared with their recommendation of 20 cfm/person for office spaces and conference rooms, 15 cfm/person for reception areas, and 60 cfm/person for smoking lounges. However, it should be noted that these recommendations are only guidelines and if additional outside air is needed to control odors and contaminants, it should be provided.

A more appropriate measurement for assessing the effectiveness of the ventilation systems would be to determine the amount of outside air being introduced to the salon. When determining outside-air-intake rates, actual air flow measurements should be collected rather than estimating the flowrate based on the position of the outside-air-intake damper.

Each of the three ventilation systems at this salon should be designed to provide outside air to its service zone at a rate based on the rate recommended by ASHRAE (25 cfm/person) and the maximum number of cosmetologists and patrons expected in its zone at any given time. To prevent airborne contaminants from stagnating, air in the salon should be distributed as evenly as possible. An air velocity of 25-50 fpm is recommended for the occupied zone (from the floor to 6 foot height).[36] The exact velocity is dependent upon the temperature and relative humidity of the air in the space.

The total measured outside-air intake rate was approximately 900 cfm, while the total measured exhaust airflow rates for the two dilution-type exhaust-ventilation systems was 740 cfm. Therefore, it would be expected that air would tend to move outward from the building (through any available openings, such as cracks around the foundation or doors) to relieve the buildup of pressure from the excess in air inducted over that exhausted -- that is, the building would be expected to be under "positive pressure." However, air flow patterns visualized with smoke-generating tubes indicated that air was infiltrating from the outside, a "negative pressure" situation.

The reason for this incongruity is uncertain. It is possible that winds affected the airflow patterns observed, but we do not believe that this was the case. Rather, we suspect that the exhaust flowrates measured may be misleading. Unlike the outside-air intake rates, these were not measured at the indoor-outdoor interface (which would be at the irregularly-shaped roof-level discharges in this case). Rather, the flow into the exhaust ducts at ceiling level was measured. If the ducts are not air-tight, additional air (not measured as part of the exhaust flow) could enter the ducts inside the ceiling plenum and be discharged outside by the fan. Also, since the constant-volume exhaust fans are rated at a total flowrate of 1000 cfm, the lower flowrates measured indicate either reduced performance (e.g., from dirt buildup), inaccurate flow measurements, or both.

In any event, the effective total outside-air intake rate on the day of the measurements was at least 900 cfm (with exfiltration occurring if the powered exhaust rate was less); it was also less than 1000 cfm, the presumed maximum exhaust flowrate (this would consist of 900 cfm from the outside-air intakes, and less than 100 cfm by infiltration to make up for any exhaust flow in excess of 900 cfm). This range of values exceeds the approximate rate of about 700 cfm which would have been recommended that day under ASHRAE guidelines, since the salon was occupied by only about 25 to 30 people during most of that day. This finding is consistent with the measurement of acceptable levels of CO_2 in the salon air at that time.

However, typical afternoon occupancy of the salon exceeds 40 people. Therefore, the appropriate outside-air induction rate exceeds 1000 cfm. Furthermore, the AHUs' outside-air intake rates are reportedly reduced during the winter, which reduces the effective total intake rate. These findings are consistent with the measurement of elevated CO_2 concentrations in the salon air during the December 1990 survey. Another reason for the elevated CO_2 concentrations was that the General Electric system serving the northeastern portion the building was not operational at the time.

Most of the chemical products used in this salon are mixed in the dispensary. The dispensary should be under negative pressure relative to the other areas of the salon to prevent heavy odor migration, should a spill occur. To accomplish this, the exhaust fan in the Dispensary should be exhausted above the roof of the building not into the ceiling plenum as was the case at the time of the survey. Exhaust air flow from the Dispensary should be at least 10% greater than the supply flow to the Dispensary. When feasible, the mixing of permanent wave solutions and all other chemical products used in the salon should be done in the dispensary.

VIII. CONCLUSIONS

Environmental data obtained during this evaluation indicated that no exposures occurred that were higher than existing **industrial** evaluation criteria.

A variety of chemicals commonly used in hair salons can cause acute respiratory symptoms.[23,28,29] Two commonly used methods for identifying potential cases of occupational asthma, symptom questionnaire and peak flow meters, were employed in this study of 33 employees at the Chapple Hairstyling Salon. Thirteen workers (39%) reported experiencing at least two symptoms consistent with asthma, but no acute airway obstruction in otherwise well employees, as is seen asthma, was found by peak flow testing. Sixty-two percent of the workers who reported respiratory symptoms associated the symptoms with one or more particular hair care products. This finding may be due to the irritant effects of commonly used hair care products.

The number of reported lower respiratory symptoms suggest that the existing **industrial** evaluation criteria may not be adequate to protect all exposed persons against the irritant effects of the combinations of chemicals used in hair salons. Additionally, the present ASHRAE recommendation of 25 cfm/person of outside air may be inadequate.

The results of the ventilation evaluation indicate an insufficient rate of outside-air induction in this facility (compared with a needed rate in excess of 1000 cfm), particularly during the winter when the outside air intake rate is reduced. Also, outside air inducted may be poorly distributed since only two HVAC systems out of three induct outside air, and because infiltration may account for some of the outside air inducted. Finally, the dispensary is ventilated by a fan which discharges potentially contaminated air into the return air plenum.

The HVAC systems apparently maintain acceptable temperatures and relative humidities during the warmer months, but it is unclear, for the reasons discussed earlier, whether this is also the case during the colder months.

IX. RECOMMENDATIONS

1. The dispensary should be ventilated by an exhaust system fan which discharges potentially contaminated air outside. It should have an airflow rate at least as great as the existing ceiling-mounted fan (which should be removed). See recommendation #3

regarding exhaust-air flowrates for more information.

2. The three HVAC systems should induce outside air at a combined rate of about 1200 cfm, sufficient for sustained occupancy of 48 persons under ASHRAE guidelines of 25 cfm/person for beauty salons. To ensure adequate distribution of this outside air, the system serving the western portion of the north half of the building (which has a General Electric AHU and refrigeration system with no heating capability, and currently handles only 100%–recirculated air) should be modified to provide outside-air intakes, or replaced with a system that has this capability. The outside-air intake rates should then be adjusted, and these flowrates measured, to assure a minimum total rate of 1200 cfm. All outside-air intake dampers should then be locked into position. The best distribution of outside air would probably occur if the Ruud package unit serving the south half of the building inducted 600 cfm and the other two systems each inducted 300 cfm.

3. Negative pressure conditions are generally not recommended for buildings for numerous reasons. These include the possibility of capture and/or re-entrainment of contaminants and odors exhausted from inside the building and/or sources outside (e.g., vehicle exhausts), respectively, as well as interference with the flue draw on gas- or oil-fired appliances. Also, air infiltrating due to negative pressure will enter by paths of least resistance rather than according to any plan, so its distribution may not occur in a desirable pattern (e.g., drafts may occur, temperatures in some areas may be hard to control, etc.). Also, if the building is under negative pressure, exhaust flow for at least some of the exhaust fans will be partially restricted as they work against a greater-than-designed pressure differential. Negative pressure leading to the infiltration of substantial quantities of air may also lead to high relative humidities in the building during the summer, as humid outside air enters the building without passing the cooling coils in the AHUs first. To avoid these problems, total outside-air intake rates for buildings should typically exceed total exhaust rates by about 5% to 10% to ensure that the building remains under slight positive pressure.(37)

   Therefore, for a total outside-air intake rate of 1200 cfm, the recommended total of the exhaust-air flowrates is about 1100 cfm. To achieve this, the actual flowrates of the existing exhaust systems must be carefully measured. Then, an exhaust system for the dispensary may be selected with a fan rated at the appropriate flowrate to achieve a total exhaust flow of 1100 cfm (as long as its flow at least equals that of the existing ceiling fan).

4. Cleaning of all AHUs within the building should be performed on a regular maintenance schedule. A record of all cleaning performed should be kept and any potential problems corrected.

5. An inventory of all products used in the salon should be conducted and Material Safety Data Sheets (MSDSs) of all products used should be obtained from the manufacturer or distributor.

6. Hairdressers should receive regular and repeated education about the potential hazards in the workplace. When possible, products not containing known chemical allergens should be substituted for those that do. Hairdressers should remain aware of work practices, such as handwashing and the wearing of protective gloves, to minimize exposure to chemical compounds.(38)

7. Hairdressers with a history of asthma or allergic reaction to chemicals, or who experience respiratory or skin irritation problems should inform their physicians about their exposures at work.

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XII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. Chapple Hair Styling Salon
2. OSHA, Region V

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table I **Indoor Air Measurements**
Chapple Hair Styling Salon
Garfield Heights, Ohio
HETA 89-138

TIME	CARBON DIOXIDE	TEMPERATURE	RELATIVE HUMIDITY
	December 5, 1990		
9:12AM - 10:00AM	600ppm - 950ppm	61°F - 70°F	28% - 70%
9:36AM (outside)	350ppm	31°F	88%
11:45AM - 12:15PM	1100ppm - 1350ppm	64°F - 70°F	30% - 60%
7:00PM - 7:38PM	900ppm - 1700ppm 2050ppm (Facial Rm)	64°F - 75°F	28% - 49%
7:32PM (outside)	400ppm	42°F	92%
	December 6, 1990		
11:25AM - 11:57AM	700ppm - 950ppm	66°F - 70°F	31% - 38%
11:57AM (outside)	350ppm	44°F	70%
1:51PM - 2:32PM	800ppm - 1200ppm	64°F - 75°F	31% - 50%
2:32PM (outside)	350ppm	44°F	70%
7:45PM - 9:03PM	850ppm - 1400ppm	69°F - 74°F	31% - 48%
9:03PM (outside)	500ppm	45°F	78%
	April 18, 1990		
12:50PM - 1:00PM	725ppm - 775ppm	73.5°F - 75°F	33% - 35%
1:00PM (outside)	375ppm	63°F	31%
1:00PM (outside)	350ppm	60.5°F	35%

ppm = parts of carbon dioxide per million parts of air
°F = temperature in degrees Fahrenheit

TABLE II
Products Associated with Symptoms
HETA 89-138
Chapple Hair Styling
Garfield Heights, Ohio

Product	No. of Workers Associating Product with Symptoms (n=13)	(%)
Hair Spray	8	(62)
Powder Bleach	7	(54)
Perm. Solution	3	(23)
Hair Dye	3	(23)
Liquid Bleach	2	(15)